IV. Data Analysis

A. *Salmonella*

1. Recovery of isolates by serotype within commodity

The total number of *Salmonella* isolates tested by year since 1997 is shown in Table 1A.

The top serotypes by commodity for 2008 are shown in Table 2A. Overall, Kentucky, Hadar, Montevideo and Derby ranked as the most prevalent serotype for chicken, turkey, cattle and swine, respectively. Using 2008 as the baseline, the relative distributions for the top five serotypes per commodity are shown in Figures 1A-4A. While Kentucky was the most frequently recovered serotype for chicken, the upward trend observed beginning in 1997 halted in 2006 at 48.8%, declined in 2007 to 44.6% and again in 2008 to 35.1% of isolates. Slight fluctuations were observed for Heidelberg from 1997 to 2002. After a decline from 2002 (26.9%) to 2004 (13.0%), recovery has remained relatively constant through 2008. For Enteritidis, an overall increase in recovery has been observed since 2002. Conversely, recovery of Typhimurium and Typhimurium variant 5- has remained relatively stable since 1997 (Figure 1A).

Among isolates recovered from turkey (Figure 2A) Hadar increased from 13.1% in 2004 to 43.5% in 2007 but declined to 27.0% in 2008. An overall decline in Heidelberg was observed from 2001 (25.8%) through 2008 (5.7%). From 2004 to 2007, antigenic formula III 18:z4,z23:- declined from 5.9% to 0.4% but increased to 9.5% in 2008.

From 2005 to 2008, recovery of Montevideo and Dublin increased among cattle isolates (from 13.1% to 23.5% and from 3.6% to 12.0%, respectively) while recovery of the other top serotypes remained relatively constant (Figure 3A).

Recovery of Derby decreased among swine from 28.2% in 2005 to 13.7% in 2007, however increased to 22.5% in 2008 (Figure 4A). From 2006 to 2008 recovery of Infantis increased from 5.3% to 13.5%. Only slight changes were noted for recovery of Agona, London, Saintpaul and Typhimurium from 1997-2008.

2. MIC distributions

The 2008 MIC distributions by antimicrobial and commodity for all *Salmonella* serotypes combined (macro analysis) are shown in Table 3A. Since it is not unusual for resistance to be driven by only a few serotypes and because the distribution of serotypes between commodities varies greatly, it is important to determine resistance at the serotype and commodity level. However, a macro analysis is often useful to quickly determine any overt change between years prior to conducting a micro analysis of the data.

The overall percent resistance by year, antimicrobial and commodity of all *Salmonella* serotypes combined is shown in Table 4A. Resistance to amikacin has only been observed once in a single isolate from swine in 2007. Similarly, with the exception of one isolate from chicken in 2003, resistance has yet to emerge to ciprofloxacin; resistance to nalidixic acid remained $\leq$ 1.0% for all commodities in 2008. In 2008, resistance to gentamicin appears to remain stable among chicken, cattle and swine (5.6%, 1.6% and 2.7% respectively). Resistance to cefoxitin, ceftiofur and ceftriaxone declined from 2007 to 2008 for chicken and turkey isolates. In 2008, resistance to the cephems class was highest among cattle isolates (14.7%, 16.3% and 16.0% respectively for cefoxitin, ceftiofur and ceftriaxone). A decline in resistance to ampicillin was observed for chicken (17.0% to 10.6%) and turkey (36.9% to 32.4%) isolates from 2007 to 2008. Resistance to the other antimicrobials varied by commodity.

A micro analysis of the 2008 data is presented in Tables 5A through 8A which shows total percent resistance and MIC distribution by commodity and serotypes. Among serotypes from *Salmonella* isolates recovered from chicken (Table 5A), Enteritidis (n=116) showed no resistance to seven antimicrobials (amikacin, chloramphenicol, ciprofloxacin, gentamicin, kanamycin, nalidixic acid, and trimethoprim/sulfamethoxazole) while exhibiting $\leq$ 2.6% resistance to amoxicillin/clavulanic acid, ampicillin, cefoxitin, ceftiofur, ceftriaxone, streptomycin, sulfonamides and tetracycline. Conversely, Kentucky (n=219) showed no resistance to four antimicrobials (amikacin, ciprofloxacin, nalidixic acid and trimethoprim/sulfamethoxazole) and exhibited varying levels and combinations of resistance to 11 antimicrobials (amoxicillin/clavulanic acid, ampicillin, cefoxitin, ceftiofur, ceftriaxone, chloramphenicol, gentamicin, kanamycin, streptomycin, sulfonamides and tetracycline).

The frequency of isolates exhibiting the ACSSuT (ampicillin, chloramphenicol, streptomycin, sulfisoxazole and tetracycline) penta-resistant pattern is reported separately for S. Typhimurium and Typhimurium variant 5- (Table 9A). Although not streptomycin resistant, ACSuT isolates are often confirmed as DT104 and have been included in previous reports (streptomycin is typically intermediate [one dilution from resistant]). In 2008, however, no *S*. Typhimurium exhibited this quad-resistance pattern.

Table 10A shows the prevalence of confirmed DT104 or DT104 complex (a closely related definitive type) isolates. However, it is important to note that presentation of the ACSSuT pattern does not always result in confirmation of the isolate as DT104 (Table 11A). Therefore, analysis of isolates by phage type enables a more accurate assessment of the prevalence and importance of DT104 or DT104 complex isolates.

The frequency and percentage of confirmed *S.* Typhimurium DT104 isolates is reported separately by food animal source from 1997 through 2008 (Table 12A). Overall, DT104 prevalence was highest in swine followed by cattle, chicken and turkey.

Specific MDR patterns by commodity are presented in Tables 13A through 16A. Data is presented by CLSI class as well as by phenotype(s) thought to be of clinical importance in humans (at least ACSSuT, ACT/S, ACSSuTAuCf or ceftiofur and nalidixic acid resistance). Overall, pan-susceptible isolates most often originated (in order of decreasing frequency) from cattle, chicken, swine and turkey. Among the clinically important phenotypes reported, resistance was least often observed to ACT/S and to ceftiofur plus nalidixic acid, for all animal sources.

B. *Campylobacter*

The number of *Campylobacter* isolates recovered by species from chicken rinsates is shown in Table 1B. *Campylobacter jejuni* were more frequently recovered than *C. coli*. The distribution of *Campylobacter* species recovered from chicken has remained relatively stable since 1998 (Figure 1B).

MIC distributions by antimicrobial and species are shown in Table 2B. No resistance to florfenicol was observed for either species. In 2008, resistance was higher for *C. coli* than *C. jejuni* for all drugs with the exception of the quinolones. *Campylobacter jejuni* exhibited more resistance to ciprofloxacin and nalidixic acid than did *C. coli*.

Percent resistance by year, antimicrobial, and species are shown in Table 3B. In 2008, a decrease in resistance from 2007 was observed in *C. coli* to the lincosamides and macrolides/ketolides. For the second consecutive year, increased resistance was observed in *C. jejuni* to the quinolones. *Campylobacter coli* were more resistant to tetracycline than *C. jejuni* from 1998 to 2004; from 2005 to 2007 *C. jejuni* exhibited more resistance to tetracycline. However, this trend switched again in 2008 as tetracycline resistance increased in *C. coli* to 60.7% which was higher than tetracycline resistance in *C. jejuni* (53.8%).

MDR by CLSI class is presented in Tables 4B and 5B. Overall, MDR has been more frequently observed in *C. coli* than *C. jejuni.*

C. *Escherichia coli* (generic)

The number of *E. coli* isolates from chicken rinsates tested is shown in Table 1C. MIC distribution by antimicrobial is shown in Table 2C.

Percent resistance by year is shown in Table 3C. No resistance has been observed to amikacin for any year. An increase in percent resistance was observed to all antimicrobials in 2008 except for sulfonamides and chloramphenicol. Only six isolates were resistant to ciprofloxacin in 2008 (0.6%).

MDR by CLSI class is presented in Table 4C. The percent of isolates that were pan-susceptible decreased in 2008 to 20.9% while resistance to multiple CLSI classes increased.
